

The Explorable Virtual Human

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Virtual Anatomy Over the Internet

- Digitized cryosectioned data is like crude oil. It is beautiful to many but not particularly useful until it has been refined.
- Our goal is to create and deliver virtual anatomy to present and future health care providers.
- The internet is a powerful delivery tool for virtual anatomy

Virtual Anatomy is a Moving Target

- Constantly Improving Segmentation
- Continued Diversity (Gender, Age, Race and Body Habitus)
- Improving Resolution and Tissue Contrast
- Adding Pathologies, Functionality, Physiology

Development and Validation of Knee Anatomy Curriculum

- Nora Hebert and Ruth Heisler, anatomists, and Lucy Eisenhart, instructional designer, developed knee anatomy curriculum
- Tim Weston of Alliance for Technology, Learning, and Society (ATLAS) headed tests of the EVH on students at red rocks community college and the University of Colorado at Boulder

What We Have Learned

- Physicians and anatomists are eager for virtual anatomy
- Today's consumer graphics cards can handle today's virtual anatomy
- The internet is not particularly 3-D friendly
- Neuroradiologists can write robust complex code

Some JAVA Concerns

- Easily Decompiled, Making it Difficult to Protect Proprietary Data
- Not Completely Cross Platform
- Extra Layer of Indirection, Garbage Collection for Example, is a Major Nuisance
- Significant Memory Overhead

The Explorable Virtual Human (EVH)

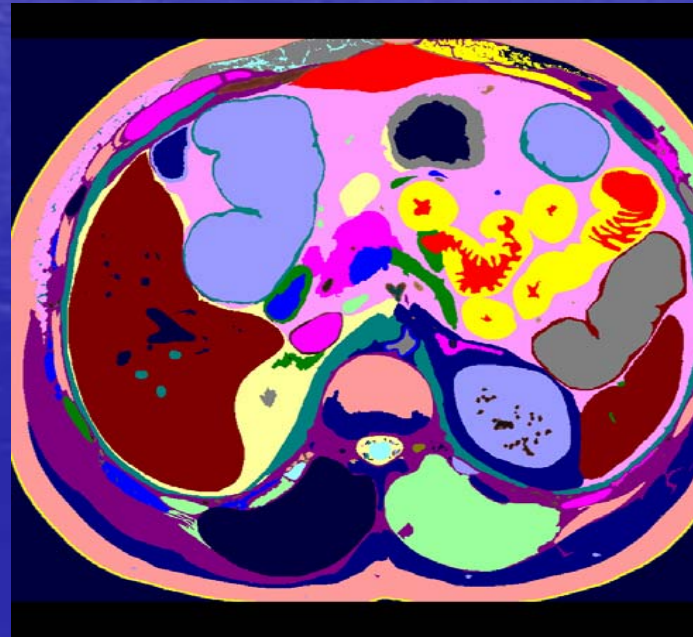
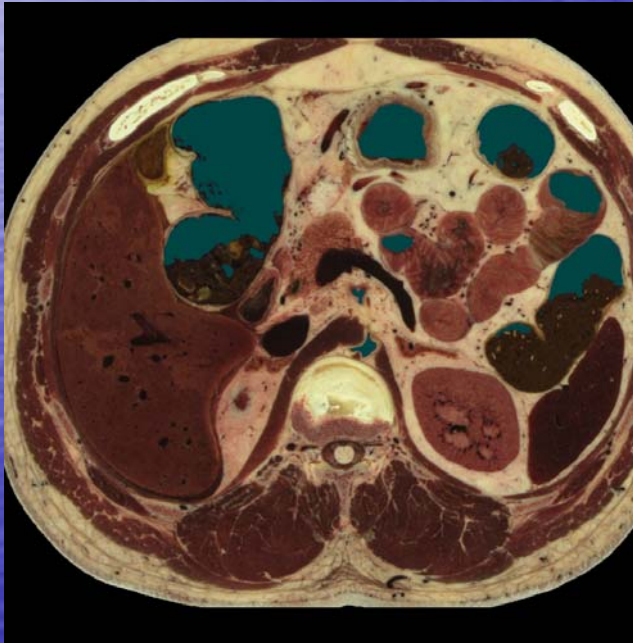
- The EVH is an authoring and display tool for delivering virtual anatomic curriculum over the internet.
- The EVH requires high-bandwidth but is highly tolerant of latency and other instantaneous interruptions such as packet loss, making it practical for the NGI of today and the near future.

EVH Objectives

- Development of a Network EVH
- Introduce EVH into Anatomy Curriculum
- Assessment for Graduate and Undergraduate Anatomy Students
- Augmentation of EVH for Surgical Simulation

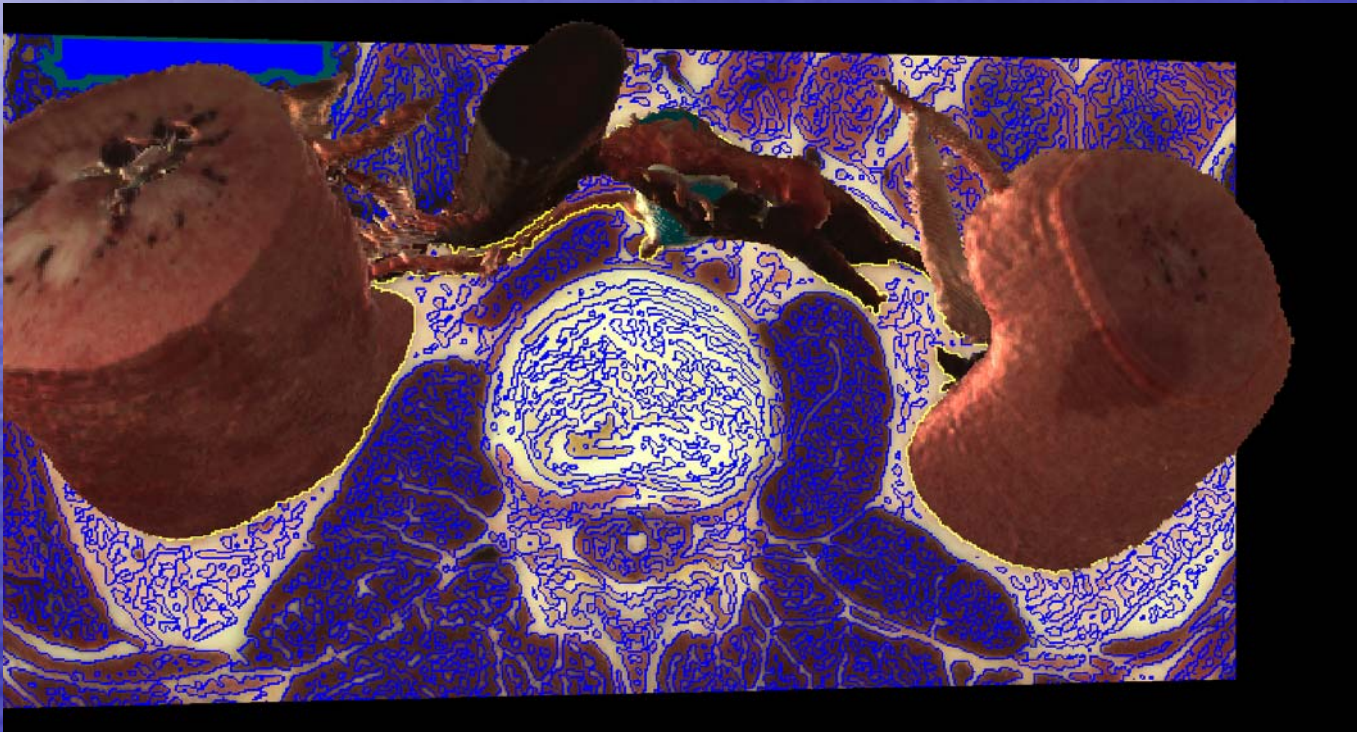
Visible Human Data

- Just a set of pictures?
- Alpha masks give geometric definition



Segmentation and Classification

- Tedious work
- Laplacian Of the Gaussian (LOG) filter can help

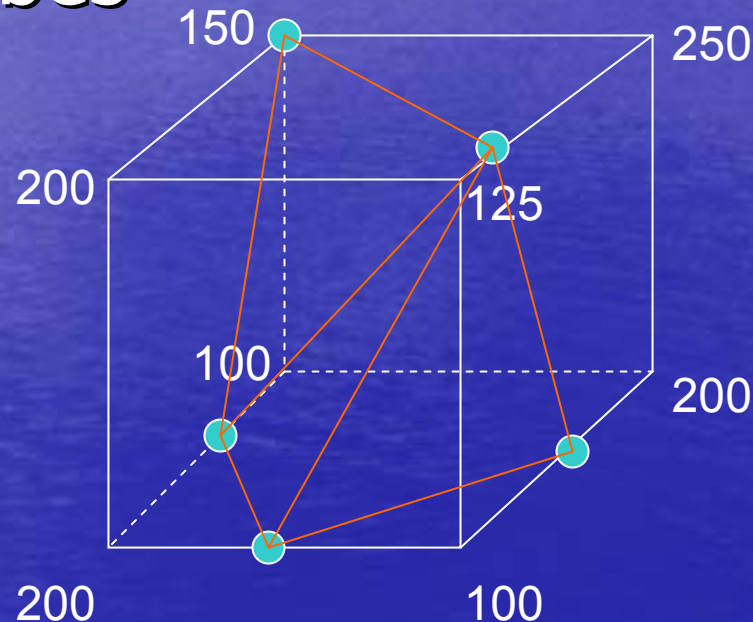


Volume Visualization Methods

- Ray-tracing
- Polygonal Texture-Mapped Models

Making Polygonal Models

- Marching Cubes



"Marching Cubes: A High Resolution 3D Surface Construction Algorithm",
William E. Lorensen and Harvey E. Cline, Computer Graphics (Proceedings of
SIGGRAPH '87), Vol. 21, No. 4, pp. 163-169.

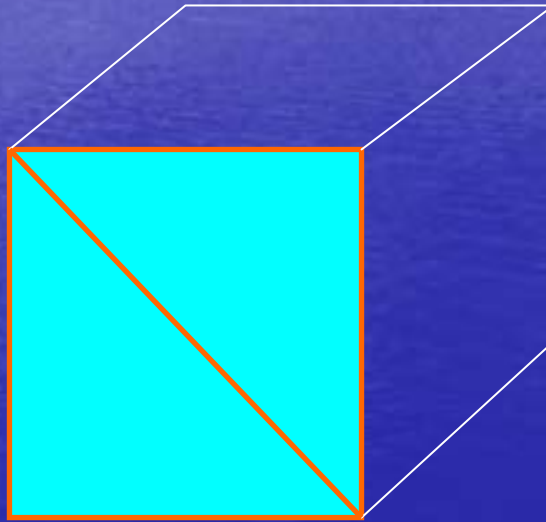
The Need for Edge Sharing Information



Our Method For Making Polygons

- Alpha data is by nature discrete
- If the smoothing can be accomplished after the polygons are made, then the algorithm for producing polygons is simple: Each voxel face that is not adjacent to a voxel of the same type is given a two triangle representation

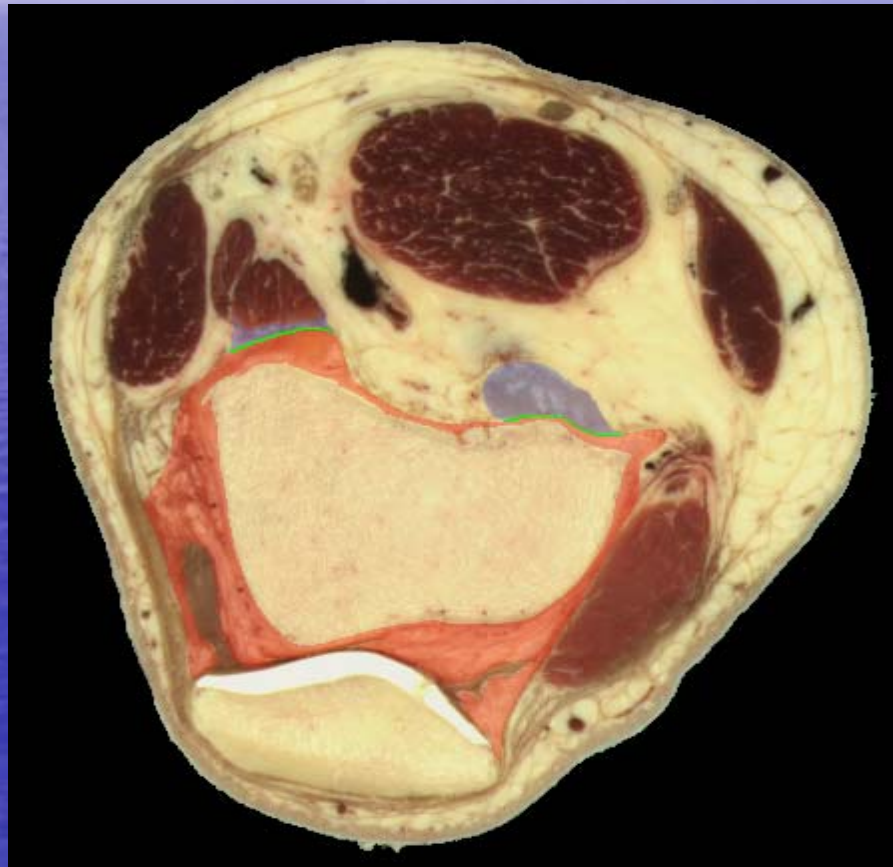
Our Method For Making Polygons



Adjacent Structures

- Adjacent structures share surfaces in one of two ways
 - They slide along each other
 - They join each other
- Many structure pairs do both
 - How they share effects the topology

Defining Edge Sharing Types



Edge Sharing Table

Fill in the data!

Choose an ID from list on left.

IDs which border it appear in the middle list.

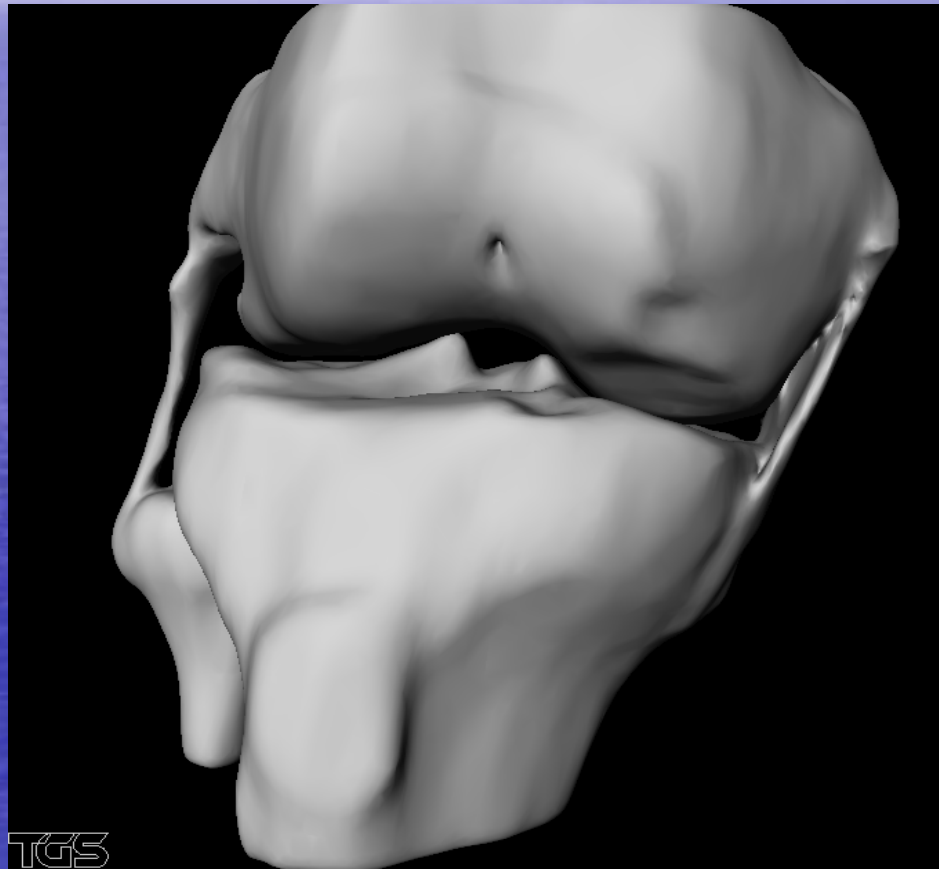
Decide whether the border IDs are attached or sliding.

Choose ID: Unknown IDs: Attached IDs: Sliding IDs:

Posterior Auricular - Left Posterior Auricular - Right Posterior Auricular Nodes - Left Posterior Auricular Nodes - Right Posterior Auricular Vein - Left Posterior Auricular Vein - Right Posterior Belly of the Digastric - Left Posterior Belly of the Digastric - Right Posterior Cerebral Artery - Left Posterior Cerebral Artery - Right Posterior Chamber - Left Posterior Chamber - Right Posterior Commissure Posterior Communicating Cerebellum Posterior Communicating Cerebellum Posterior Cord of the Brachial Plexus Posterior Cord of the Brachial Plexus Posterior Cricoarytenoid - Left Posterior Cricoarytenoid - Right Posterior Cruciate Ligament - Left Posterior Cruciate Ligament - Right Posterior Cusp of the Aortic Valve Posterior Cusp of the Mitral Valve Posterior Cusp of the Tricuspid Valve Posterior Division of the Inferior Trunk Posterior Division of the Inferior Trunk Posterior Division of the Middle Trunk Posterior Division of the Middle Trunk Posterior Division of the Superior Trunk	Anterior Cruciate Ligament - Right Connective Tissue Distal Femoral Cartilage - Right Femur - Right Fibrous Capsule of the Knee Joint Lateral Meniscus - Right Medial Meniscus - Right Synovial Cavity of the Knee Joint Tibia - Right	Cartilage of the Proximal Tibia	
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QUIT SAVE Make Unknown Make Attached Make Sliding

Smooth and Disjoint



The EVH as a Display Tool

- HTML
 - Text
 - Audio
 - Movies
 - Links
- Interactive Anatomic Animations (IAAs)
- Haptics

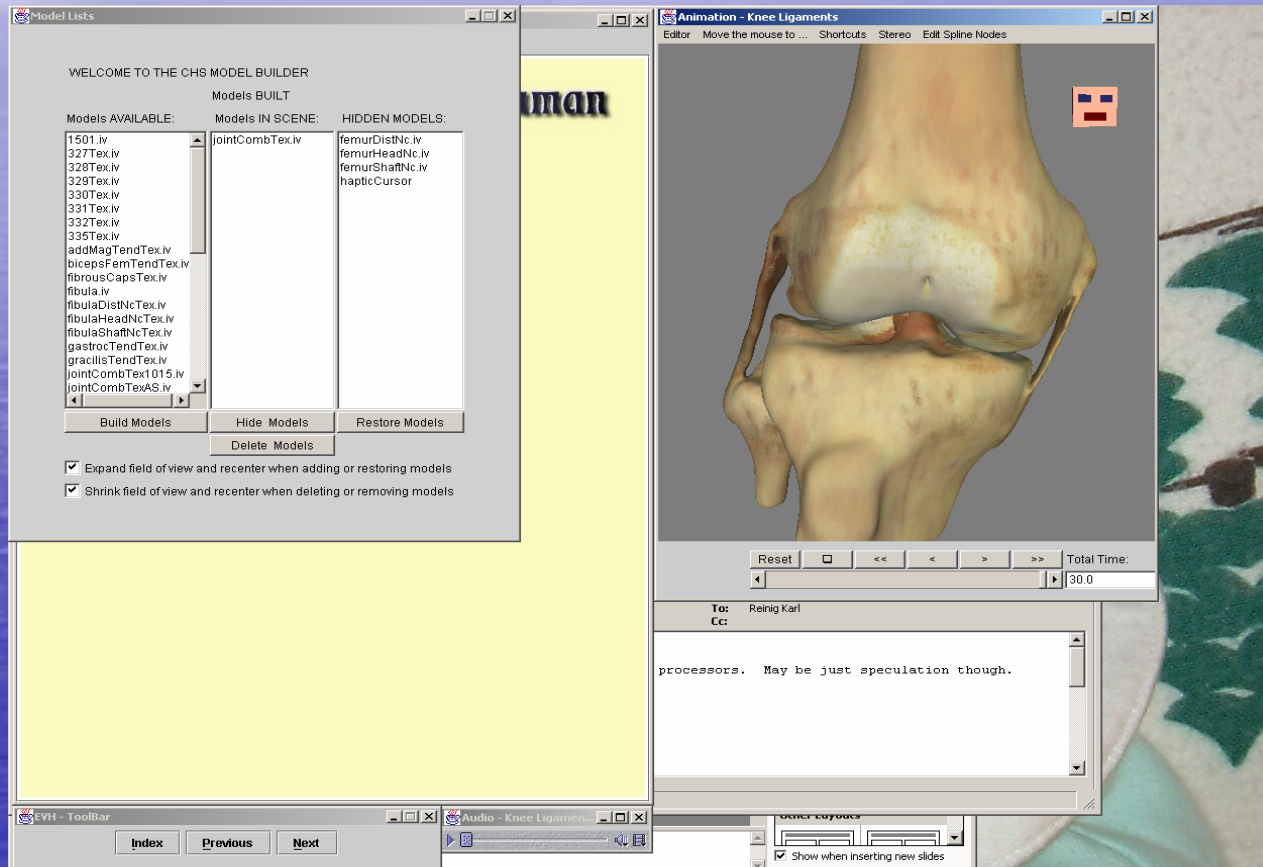
The EVH as an Authoring Tool

- Create/Edit
 - IAAs
 - HTML
- Create and Import Sound Clips
- Import Movies

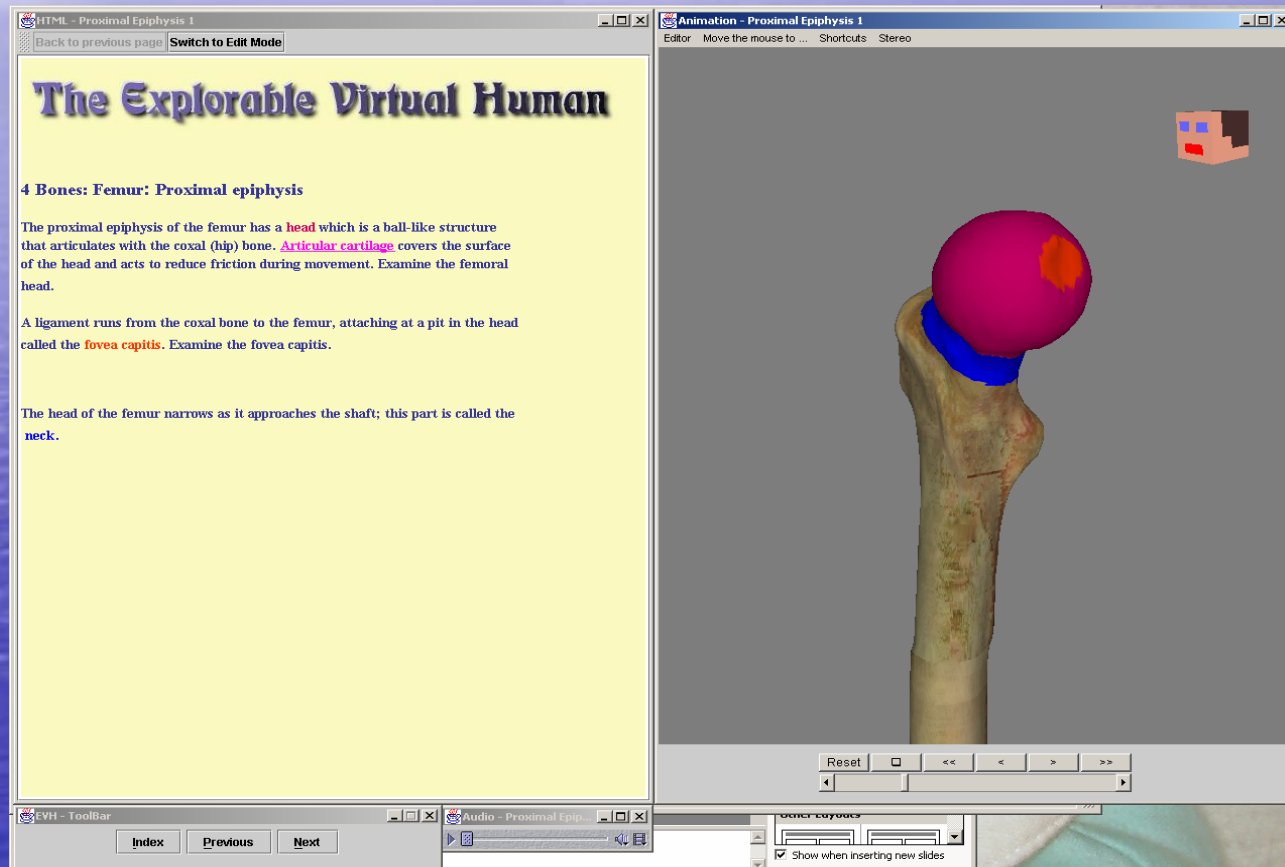
IAA Editing

- Select Structures
- WYSIWYG Spline Path Camera Motion
- Toggle
 - Transparency
 - Highlighting
 - Visibility
- 3-D Painting

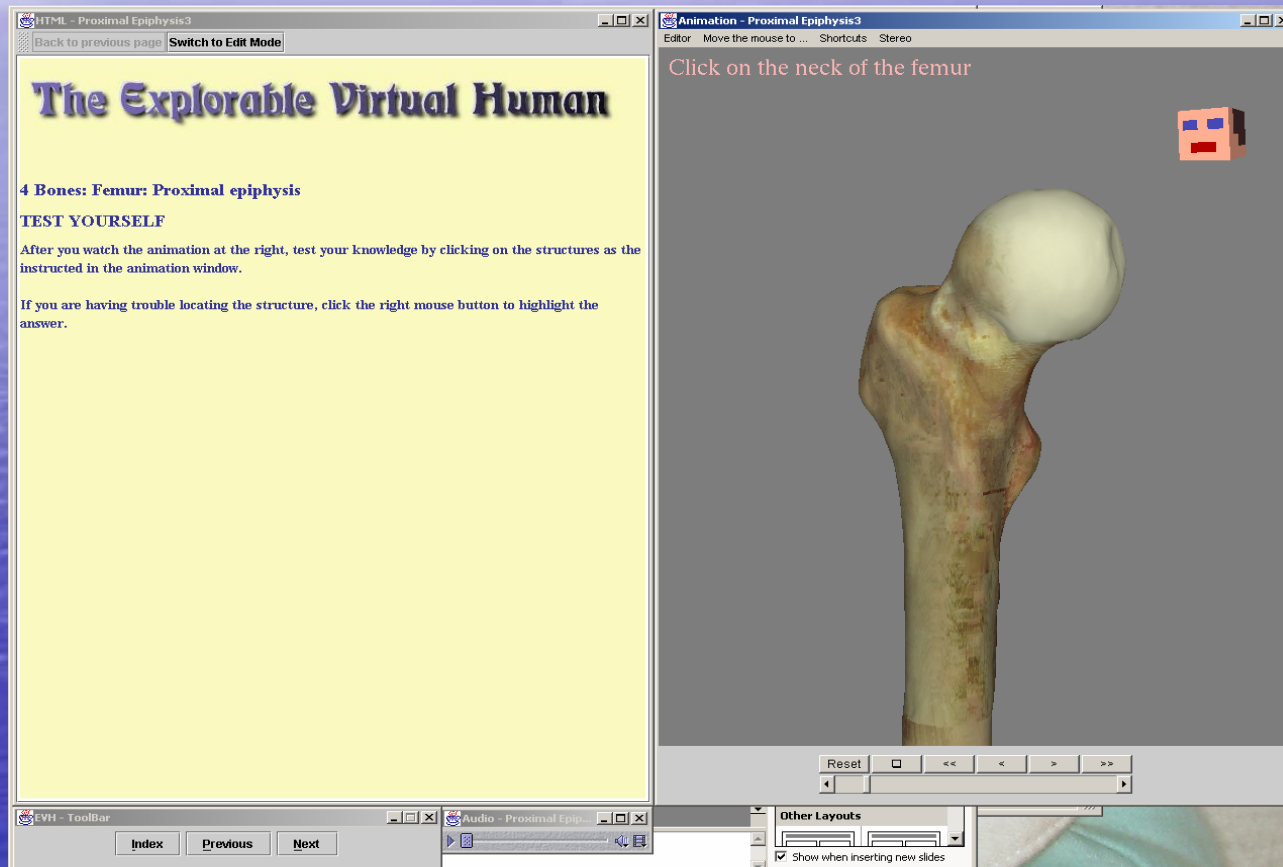
Editing



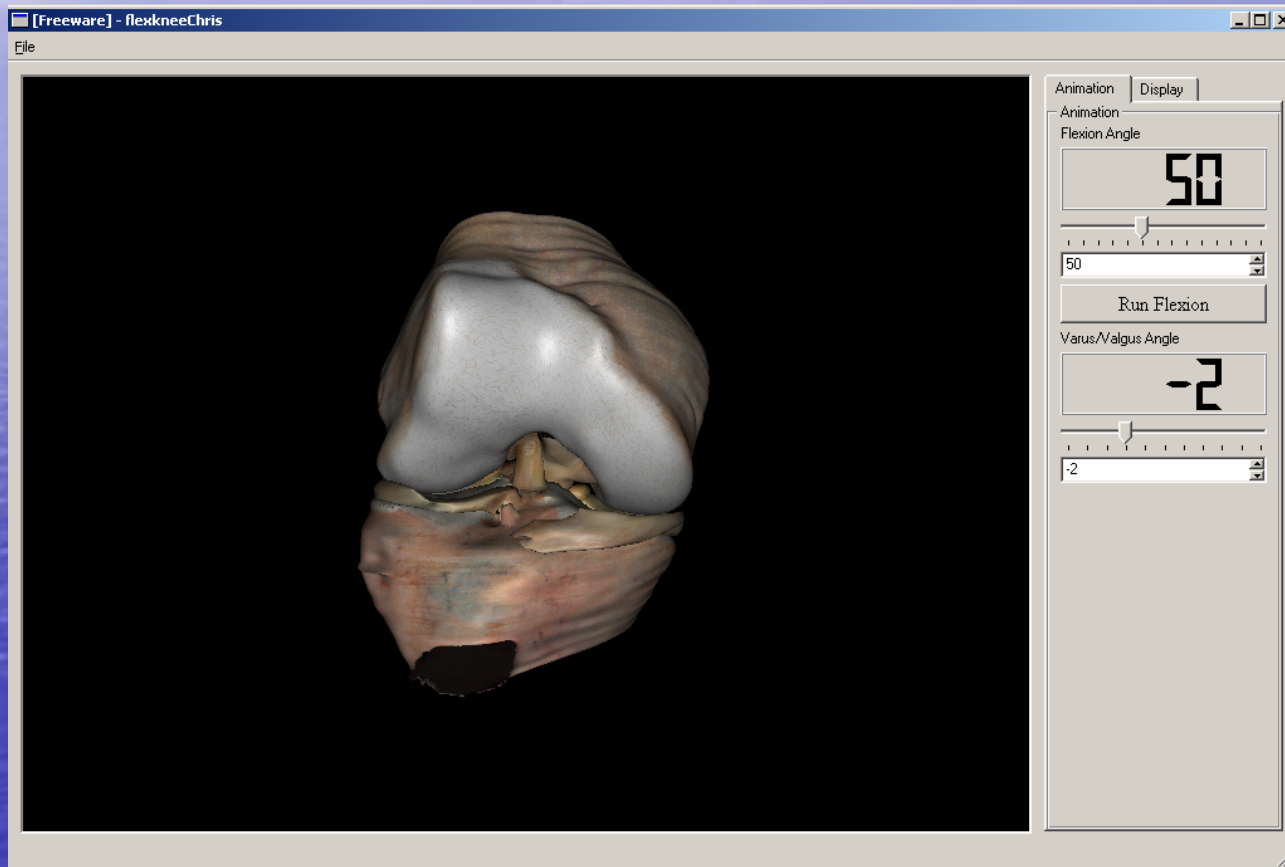
3-D Painting Allows Delineation of Surface Features



Questions Are Added that Depend On the 3-D Surface Painting



Soft Tissue Deformation



Haptics

- Haptics Run in Native Code (C++)
- Supports Either GHOST or Our Own API
- See Video

Hardware Controlled Knee Joint (HCKJ)

- An Input Device for Simulated Arthroscopy
- Measure:
 - Flexion
 - Varus / Valgus Forces
 - Tibial Internal / External Rotation

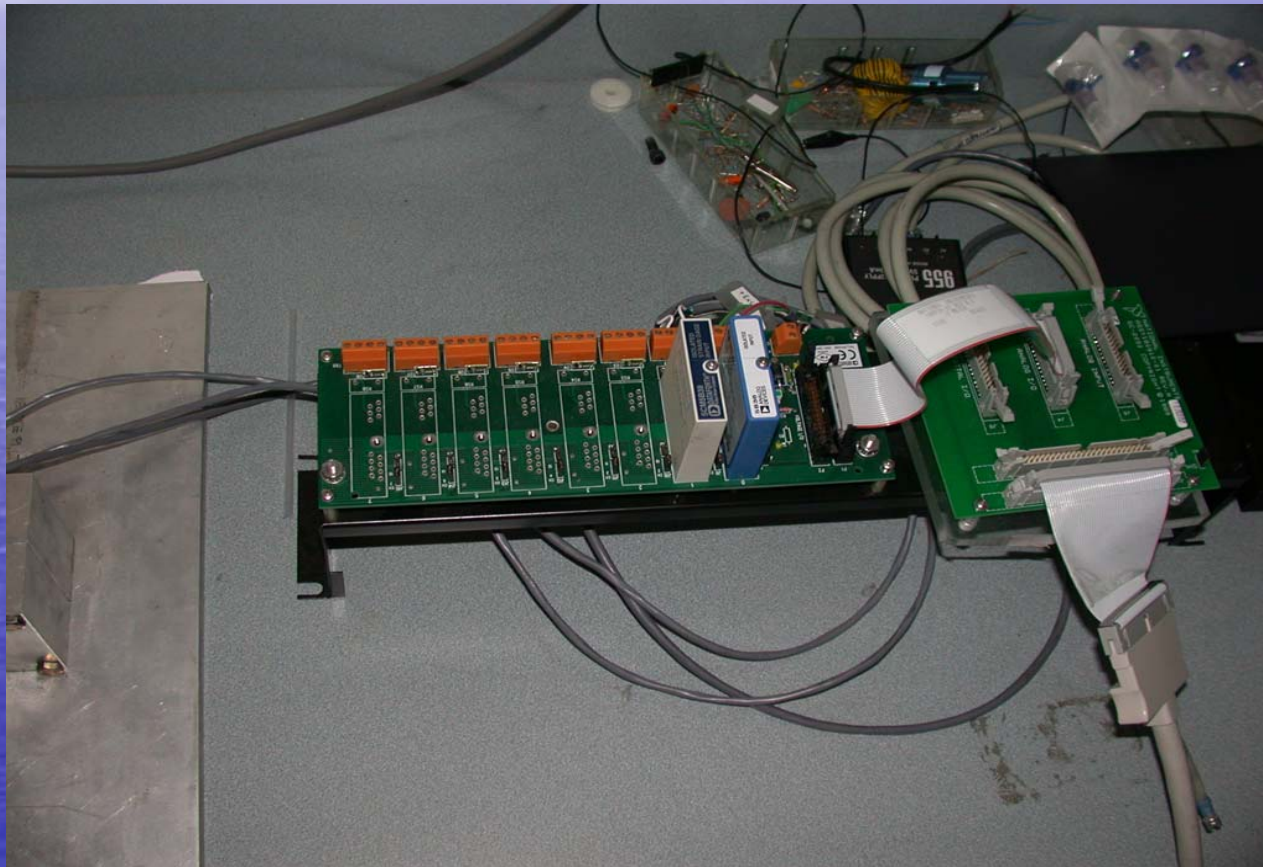
Hardware Controlled Knee Joint (HCKJ)



HCKJ Hardware



HCKJ Electronics



Latest Incarnation



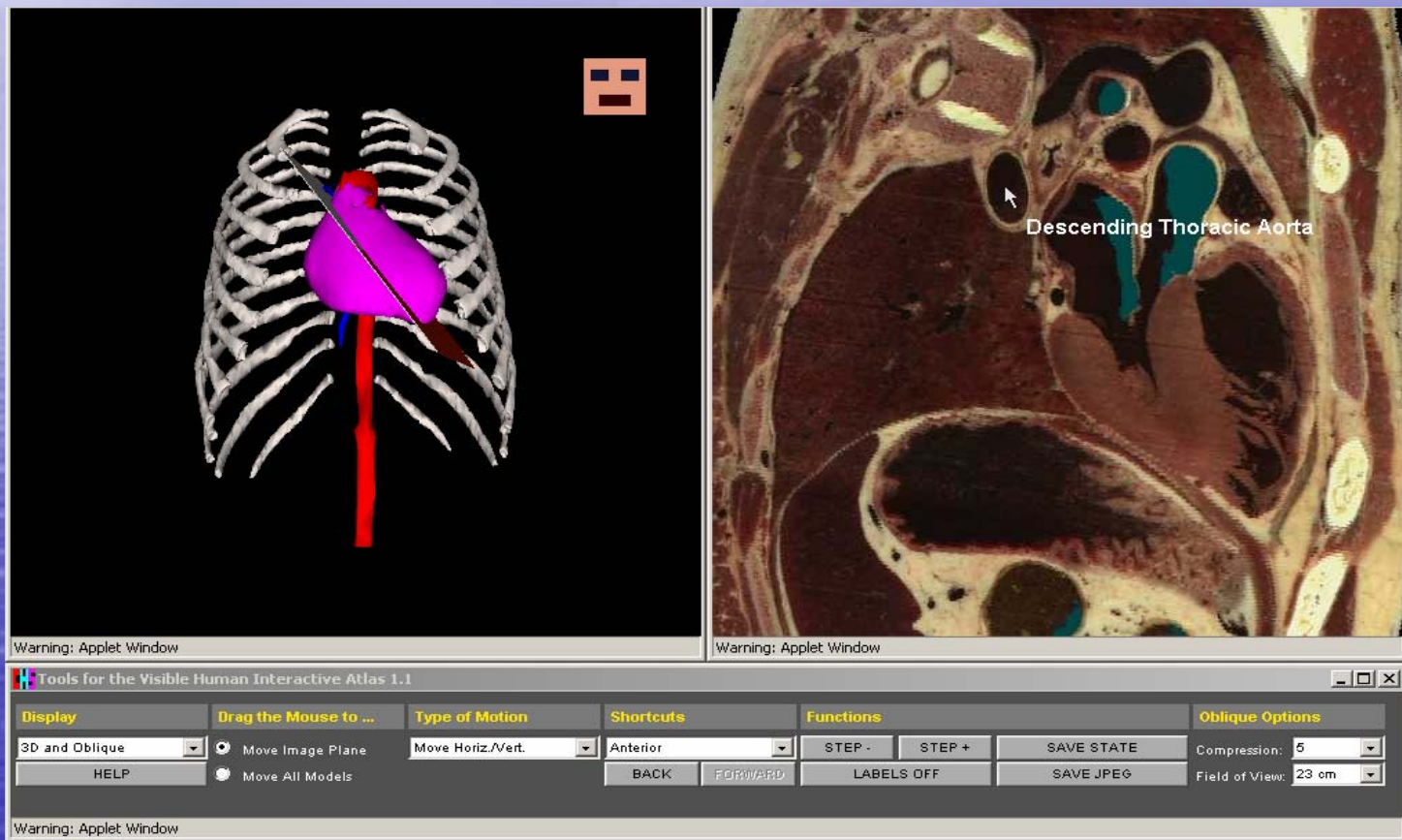
The Next Step



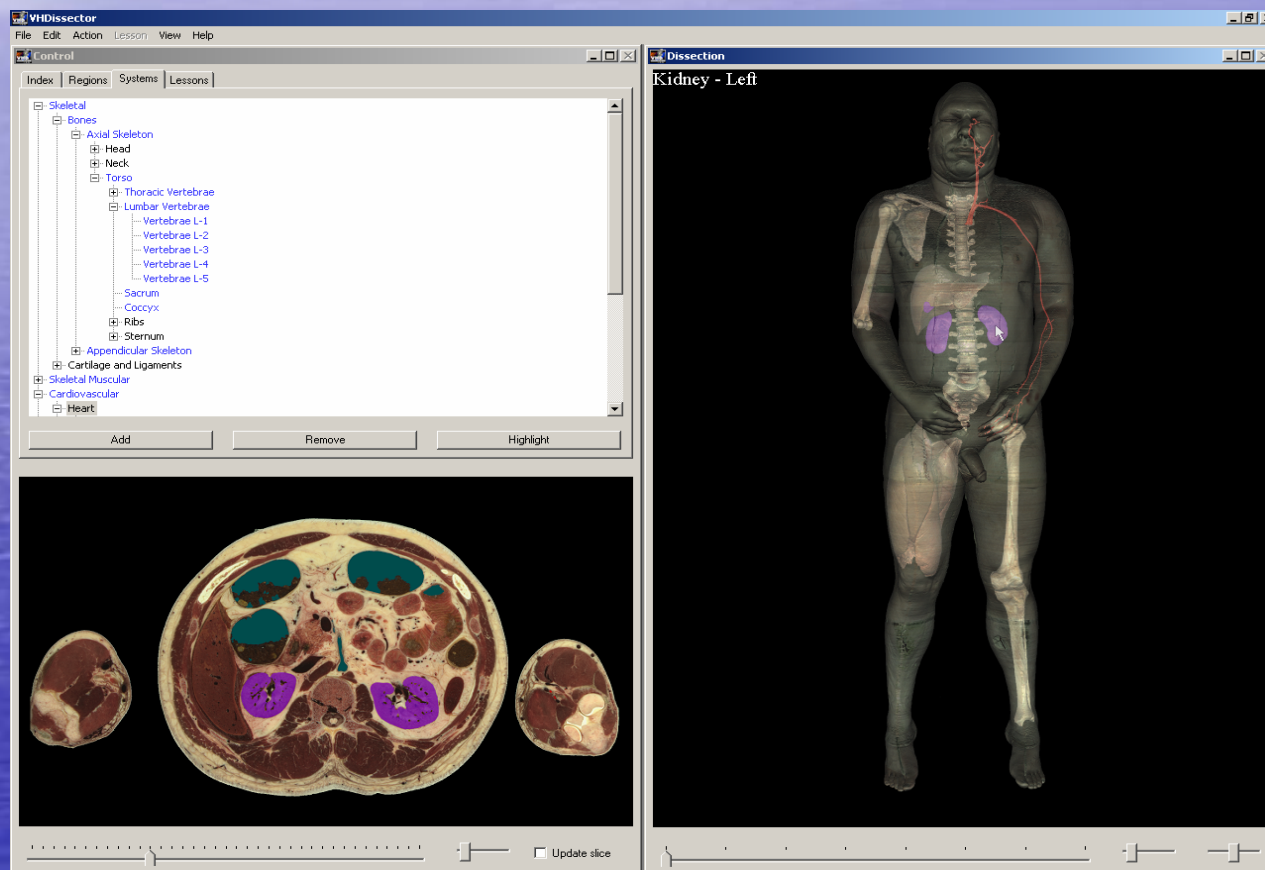
Derivative Applications

- Interactive Atlas (Obliquemaker)
- Multimedia for the VH Dissector TM
- Clinical Specialty Projects

On-Line Interactive Atlas



VH Dissector™



Explaining Subtleties of the Flexion Axis

NGI - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Address W:\users\reingh\AAOS_2002\start.html

[Home](#) [Tutorial](#)

This IAA illustrates the difference between the two axes, which are neither colinear nor parallel.

[Replay](#)

The following IAA shows that the corresponding two planes are neither coplanar nor parallel.

[Click to explore](#)

The angle between the two axes is 6.76 Degrees.

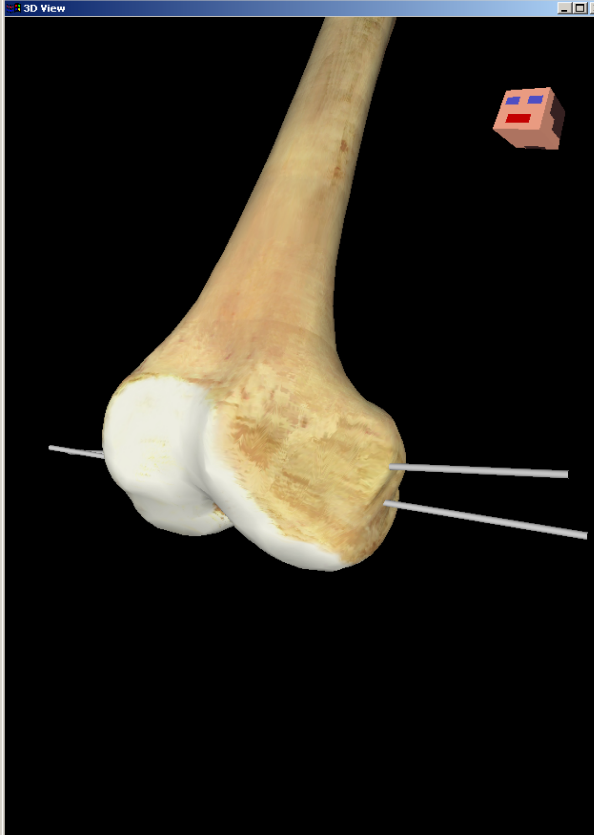
For the CT knees, the angle between the two axes were:

knee1	7.6
knee2	10.7
knee3	14.2
knee4	7.1
knee5	1.11
knee6	1.83
knee7	9.02
knee8	1.25

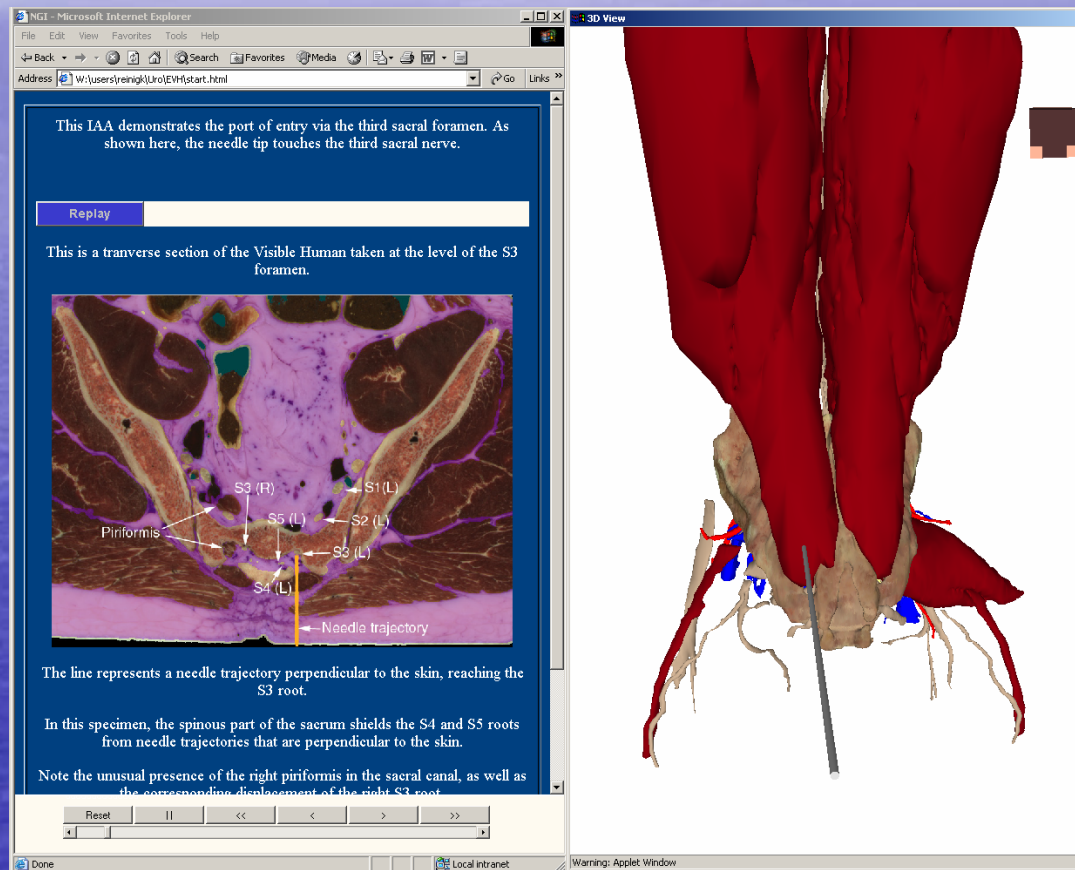
Reset II << < > >>

Done Local intranet Warning: Applet Window

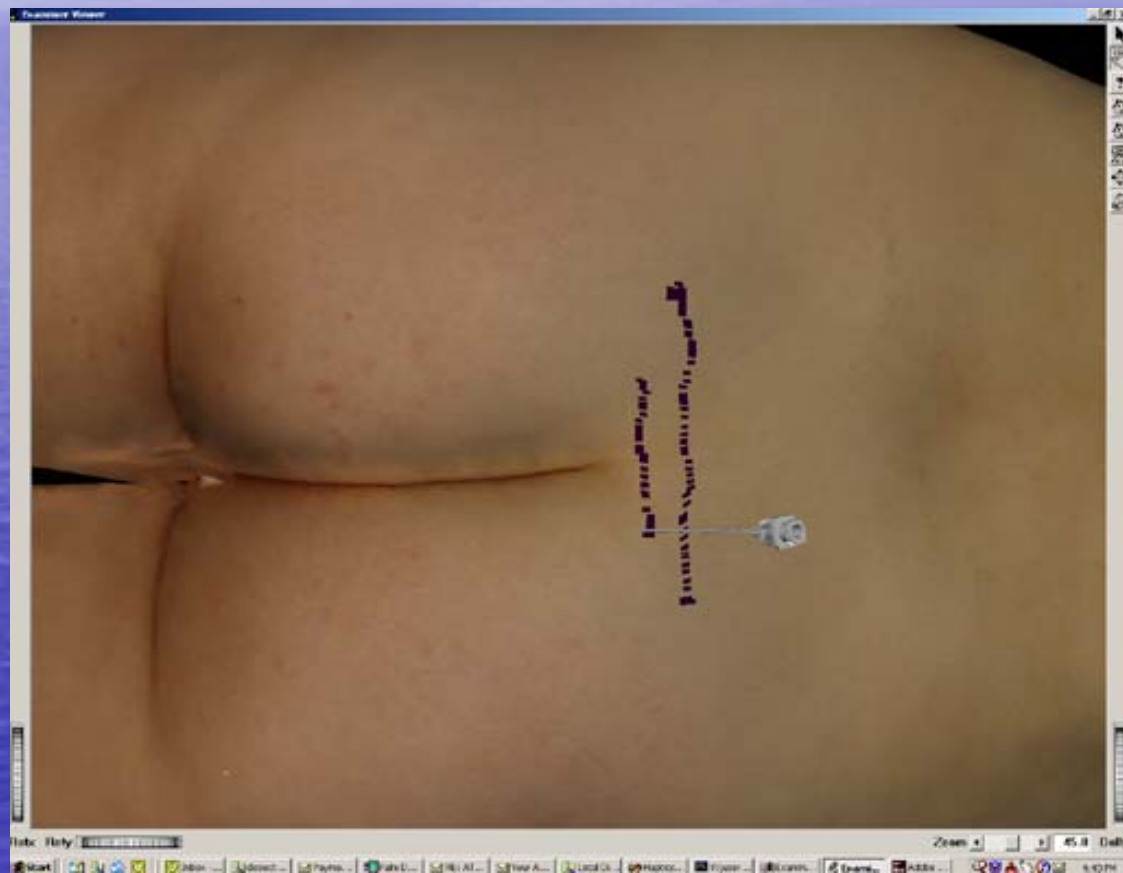
3D View



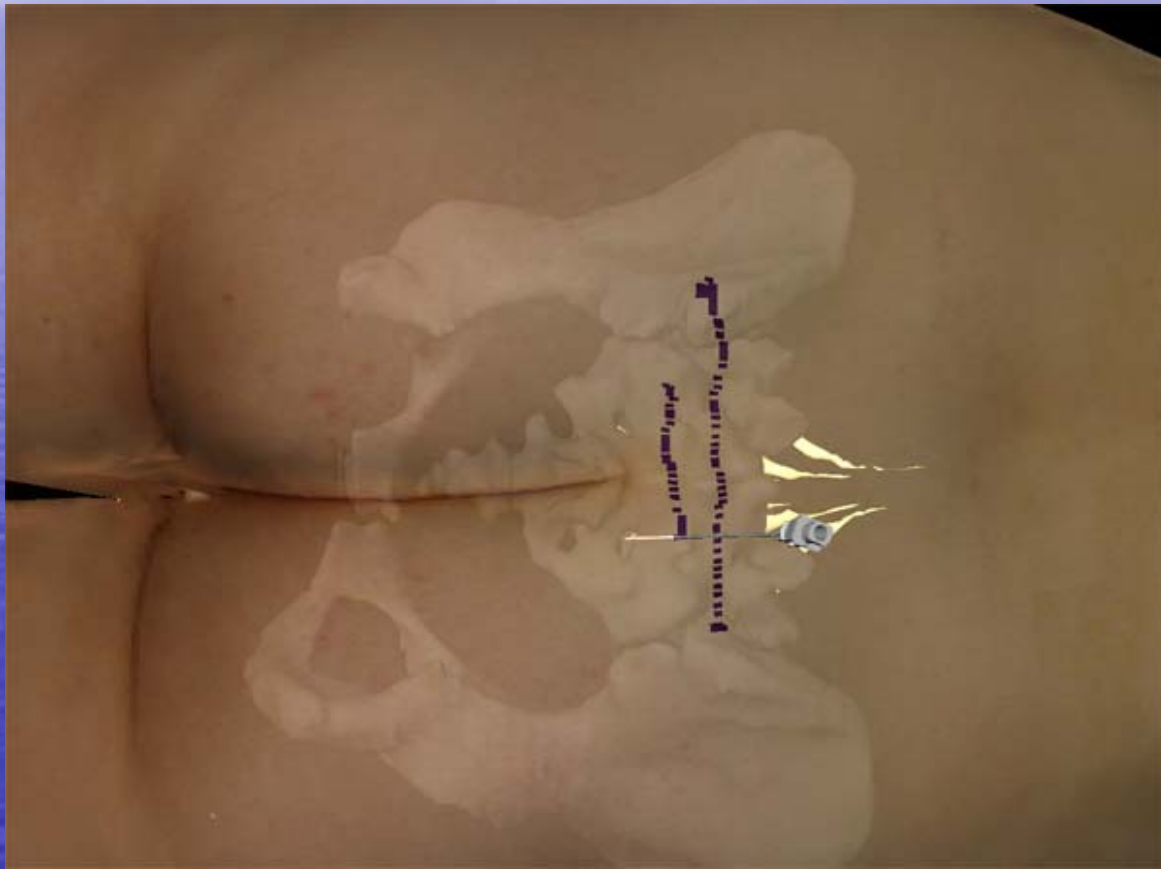
Sacral Stimulation



Sacral Stimulator Simulator



Sacral Stimulator Simulator



Neurosurgery Simulator



Significant Impact On

- Anatomy - Medical & Undergraduate Education
- Orthopaedics - TKA basic research
- Orthopaedics - Surgical Simulation
- Urology – Sacral Stimulation Simulation
- Gastroenterology – Planer Anatomy
- Neurology – Needle Insertion Simulation

Where Must We Go From Here

- Develop anatomy curriculum for the rest of the body.
- Develop an economic model for delivering this to the health professional world.
- Grow from anatomy to medicine!